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The first Ichneumonid fossil from the Early Pleistocene of Madeira Island (Portugal)

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Abstract: In oceanic islands, well age-constrained deposits containing arthropod somatofossils (body fossils) are rare. However, when available, these are important for providing empirical and independent minimum ages for molecular phylogenetic dating and complementary data on taxonomy, evolution and palaeobiogeography information of the biological groups found as fossils. This is especially important for taxa that speciated within oceanic islands, many becoming single island endemics (SIE). Recently, associated with a 1.3 Ma (Calabrian) fluvial and lacustrine sedimentary deposit from Porto da Cruz in Madeira Island (Fig. 1), a wing, putatively identified as Hymenoptera, was found. Here we describe this wing fossil as belonging to Ichneumonidae, a group with ca. 30% of SIE in Madeira Island. Moreover, this is the first somatofossil of ichneumonid parasitic wasps found in Madeira Island and in Macaronesian islands (i.e. Azores, Madeira, Canaries and Cabo Verde).

Since the 19th century, oceanic island attracted several naturalists due to the high probability of finding taxonomical novelties (e.g. Vieira, 2005). Darwin (1859) amplified this interest, as oceanic islands biota presented a central role to explain evolution. Today oceanic islands became the ideal locations to study evolution, biogeography and ecology (e.g. Whittaker *et al.*, 2017).

Madeira Island (Central Atlantic Ocean; Fig. 1), geologically a shield volcano of 7 Ma (Ramalho *et al.*, 2015 and references therein), is considered an insect diversity hotspot where 3019 species and subspecies are known, of which 665 are SIE (Borges *et al.*, 2008). This diversity is most probably explained by stepping-stone through palaeo-Macaronesian islands and isolation (Triantis *et al.*, 2010; Fernández-Palacios *et al.*, 2011).

Palaeoentomological records are rare in Madeira. The only known record is from the Mio-Pleistocene deposit of São Jorge (see Góis-Marques *et al.*, 2018), where Heer (1857) described an extinct coleopteran, *Laparocerus wollastoni,* based on fossilized elytra. Machado (2006) in a taxonomic review of *Laparocerus* considers this taxon as *nomen dubium*, due to the missing holotype and the impossibility of reapraising its taxonomy. On other Macaronesian archipelagos, especially in the Canaries Islands, several deposits with insect ichnofossils have been described (e.g. Edwards & Meco, 2000; Meco *et al.*, 2011; La Roche *et al.*, 2014). In Azores only xylophagous ichnoentomological traces in charcoal wood are known (Góis-Marques *et al.*, 2019b).

The fossil wing was found within laminated lacustrine fine sandstone, associated with plant fossils. The sediments are constrained by two ^{40}Ar-^{39}Ar dates to 1.3 Ma, Calabrian stage (Góis-Marques *et al.*, 2019a). Fossils are kept in the palaeobotanical collection at the Madeira University herbarium (UMad-P) with the numbers UMad-P500a (part) and UMad-P500b (counter-part). The wing fossil was studied under a stereo microscope, and its identification was performed through several sources (e.g. Goulet & Huber, 1993) and specific guidebooks (Prehn & Raper, 2016). Wing description follows the Comstock-Needham system as described by Quicke (2015).

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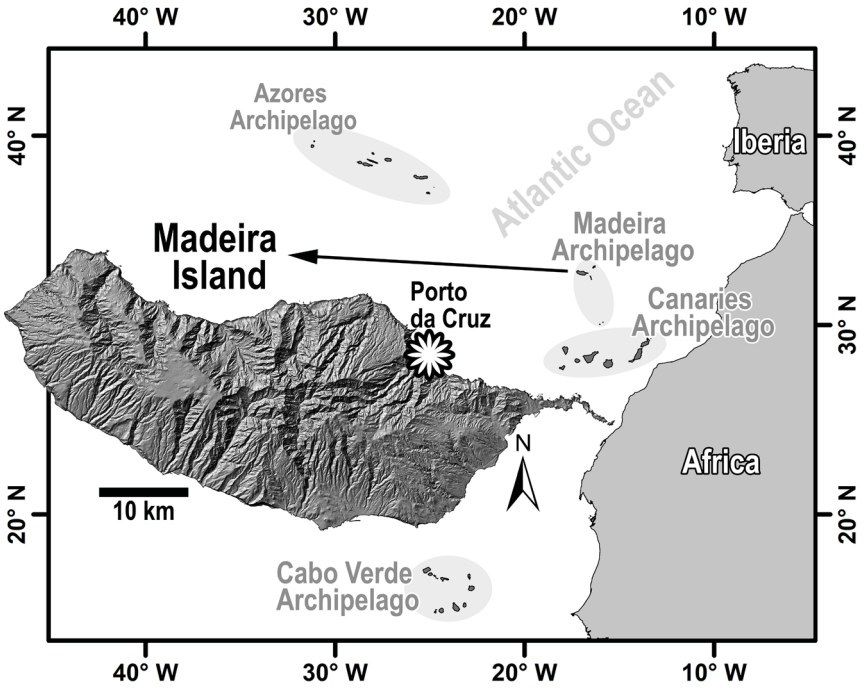

FIGURE 1. Geographical location of Madeira Island and the Porto da Cruz locality.

Systematic palaeontology

Order Hymenoptera Linnaeus, 1758

Family Ichneumonidae Latreille, 1802

Genus and species indet.

Material: UMad-P500a (part: Fig. 2B) and UMad-P500b (Counter-part: Fig. 2C).

Description: Incomplete hind wing, composed of incarbonized venation, 10.6 mm (base of wing to the RSb apex) × 3.16 mm (2A apex to SC+R), venation more or less complete, except R1, and the missing vein C; bulla present in rs-m and CU-a. Vein 1-A partly detached from the sediment.

Remarks: Hind wing fossil architecture and size correspond to the Ichneumonidae (Fig. 2A). It is distinct from similar Braconidae hind wings, due to the enclosed VI cell (Fig. 2A and D) (Broad, 2011), and vein rs-m apical to separation of veins RSa and RSb (Goulet & Huber, 1993). Further identification is prevented, although the size and venation points to a large ichneumonid parasitoid wasp. Genera with similar hind wing size and venation occur today in Madeira, including *Amblyteles, Ophion*, *Ichneumon,* and *Rhyssa* (Aguiar, 2008; Aguiar *et al.*, 2017). However, to identify the specimen to genus and/or species, more complete fossil specimens are needed, as Ichneumonidae taxonomy is based on fore wing and body morphology (e.g. Goulet & Huber, 1993).

Today, Madeiran Ichneumonidae are represented by 98 spp., of which, 30 spp. are single island endemics (Aguiar, 2008). Notwithstanding the high number of endemic species, literature reveals that Madeiran ichneumonids are understudied, being restricted mainly to check lists and taxonomy (e.g. Aguiar, 2008; Aguiar *et al.*, 2017). Recent efforts include those of Santos *et al.* (2011), who demonstrated through host dissection and DNA barcoding that on Macaronesian Islands, parasitoids including Ichneumonidae, had a higher number of generalists (idiobionts) when compared to mainland. Studies dealing with immigration, evolution and divergence of ichneumonid parasitoid wasps in Madeira are currently lacking. However, the existence of a parasitoid wasp in Madeira Island at 1.3 Ma, certainly points to a complex trophic system already installed in the island.

We conclude that insect somatofossils on oceanic islands are rare, but when found, they can provide interesting palaeontological information. The specimen described is the first record for Madeira island and Macaronesia. It corresponds to a fossilized hind wing of an ichneumonoid parasitoid wasp from the Calabrian stage (1.3 Ma) in Madeira Island, implying also the existence of their hosts. Further entomological and palaeoentomological efforts are needed to understand the evolution of these wasps in an insular context.

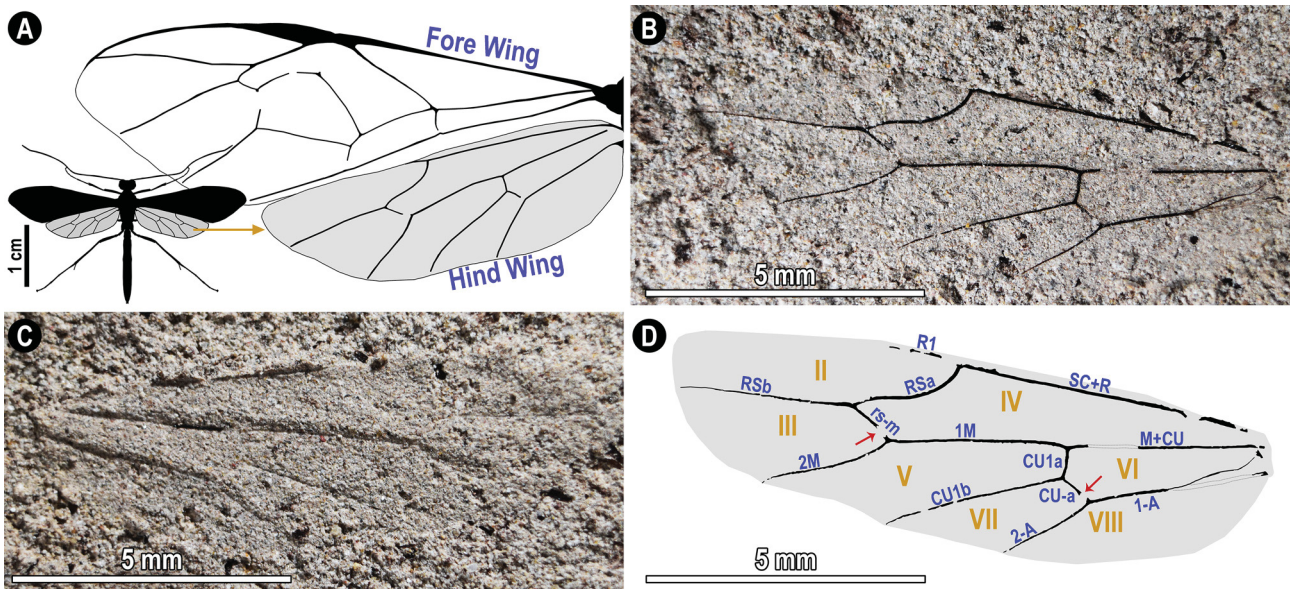

FIGURE 2. Ichneumonidae hind wing morphology and comparison with the wing fossil. **A**, position and venation in Ichneumonidae (*Ophion obscuratus* Fabricius, 1798), figure adapted from Prehn & Raper (2016); **B**, Specimen UMad-P500a (part); **C**, Specimen UMad-P500b (counter-part); **D**, drawing interpretation of specimen UMad-P500a with venation nomenclature and cell numbers; arrows point to bulla.

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